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Simulation of Two Conventional Current Control Methods : CHC and VOC

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Abstract

Before 1980 the applications of high power transformer systems limited to HVDC and electronic A-synchronous extinction machines and speed variation of these machines. But in latest of 1980 decade the power electronics applications increased due to development of semi conductor switches and tendency to restructuring electrical power systems. Now power electronics applications have a wide range such as power generation, transmission and distribution. This is obvious that efficient power electronic converters strongly related to a suitable control strategy. In past years power generation from small scales renewable energy sources give more attention. So in this paper we focused on two conventional control methods, current hysteresis control (CHC) and voltage oriented control (VOC) and after brief performance explanation for each method we bring simulation and its results.

***Keywords:** Small-Scale, Single Phase Grid-Tie Converter, Control.*

1. Introduction

Increase of demand on reliable electrical energy becomes a main concern in electricity sector. At this moment the primary source of electricity generation is fossil fuel that the most drawback of this source is environment pollution. [1] So governments and NGOs insist on generating energy should be from renewable energy. With changing life style in developing country, millions people willing to enjoy more from electricity to have a comfort life. We need to pay attention to their compatibility with the environment with the increasing expansion and improved technologies. Low consumption of fossil fuels is in top priority of every nation across the world. One of the important actions taken by different countries is investing in the renewable energy field. Some big countries like China and USA do important activities in renewable fields. The Figure 1 shows the share of renewable and hydro energy in the United States in 2013 is about 13 percent. In the global index, Share of renewable energy and hydro that contain a variety of sunlight, wind and biomass is about 19 percent. [1-3].

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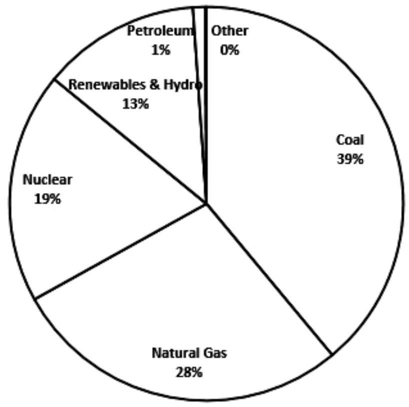

Figure 1: Shares of Energy Sources

In the last few years, we have witnessed the growing of all types of renewable energy. According to the following Table 1, we find that in 2013, total growth of all kinds of renewable energy is better from year 2012. Although some growth is negative and some growth is very significant. Due to the Table 1 we find that the annual growth of the renewable energy is constantly rising. In 2010, about 1/3 the capacity of newly power manufacturing was from renewable sources. On the other hand the environmental risks from fossil fuels and increasing greenhouse gas emissions helped the importance of the growth of this type of energies [4,5].

But along this expensive plan to increase consumption of renewable energy, small-scale renewable energy sources, such as small hydro turbines and wind turbines and roof-mounted Photo Voltaic plane can play an important role in energy crisis. We can see a general structure of small converter in Figure 2 that use for single phase grid. As we can see in left hand after extraction

TABLE 1: WORLDWIDE INSTALLED POWER CAPACITY OF RENEWABLE ENERGY TECHNOLOGIES FOR GRID-CONNECTED POWER GENERATION AND ESTIMATED ANNUAL ENERGY GENERATION IN 2013.

Renewable Energy Type	Cumulated installed capacity 2013 (GW)	New installed capacity 2013 (GW)	Growth of cumulated installed capacity (%)	Growth rate of newly installed capacity (2012-2013) (%)
Hydropower	1103.8	39.9	5%	35%
Wind Power	315.7	35.4	13%	-21%
Solar PV	134.7	36.3	41%	25%
Solar CSP	3.8	1.2	56%	63%
Biomass	88.0	4.3	5.1%	-55%
Geothermal	12.0	0.5	4%	42%
World Total	1658.0	117.5	21%	15%

of energy from renewable sources it transfer to a DC power supply which is Flooded type batteries, Gel type or Absorbed Glass Mat (AGM). We use Voltage Source Converter (VSC) that is best for single phase converter. There is numerous way that suggest to reduce output current harmonic with current controller method such as current hysteresis control (CHC)[6-10] and voltage oriented control (VOC)[11-14] that are subject of this paper.

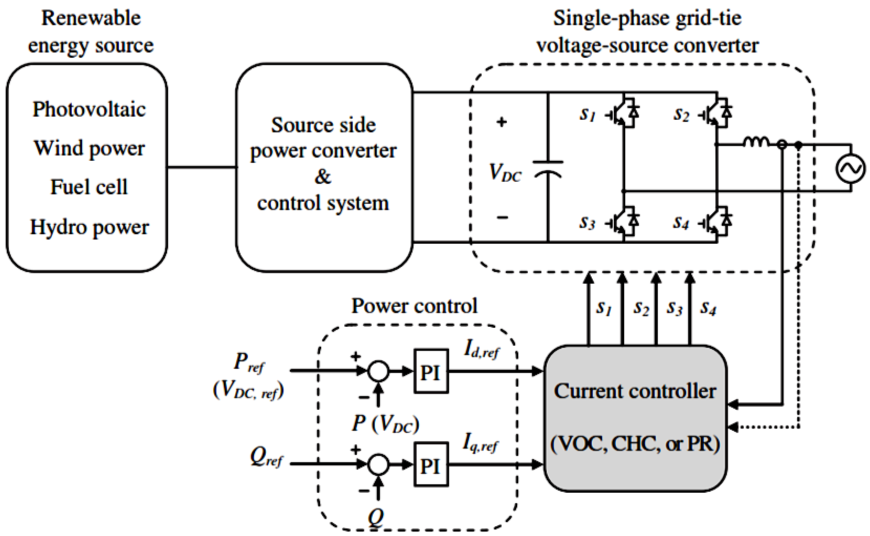

Figure 2 : structure of a small-scale converter

2. Strategies for single-phase converter

Due to using Voltage Source Converter (VSC) structure, we use a parallel capacitor to cancel voltage ripple. In VSC structure we use active and reactive power as reference signal. After defining the power that flows in grid we use it as feedback and after calculating reference error it feed to our controller. Due to using advance current controller strategies this is necessary to using decupled current as signal error. The switch state produce based on our control method and it gives to converter switches.

Quality of output current and efficiency of controller is directly depending on the method that we choose. CHC and VOC are two common methods that in recent years more studies are done. In Figure3 structure of two methods is given that simulations are based on it.

2.1. Current Hysteresis Control (CHC)

This method is one of the easiest control ways that this method controls AC current with changes around the sine wave reference. For this topic using hysteresis controller can increase dynamic and makes it simple. The output of the hysteresis controller can be used for switching, for this reason we don’t need PWM and this makes more dynamic and simply structure. With this Simplicity this method has high dynamic and good stability, but this method has some weaknesses, such as changing the switching frequency and high current ripple. According to the switching frequency depends on hysteresis bandwidth, so the sampling frequency, the system parameters and load is changed in a wide range. As a result low-order harmonic in current is evident with remarkable values and it is important that filter design in the same way in power sector will be carefully design.

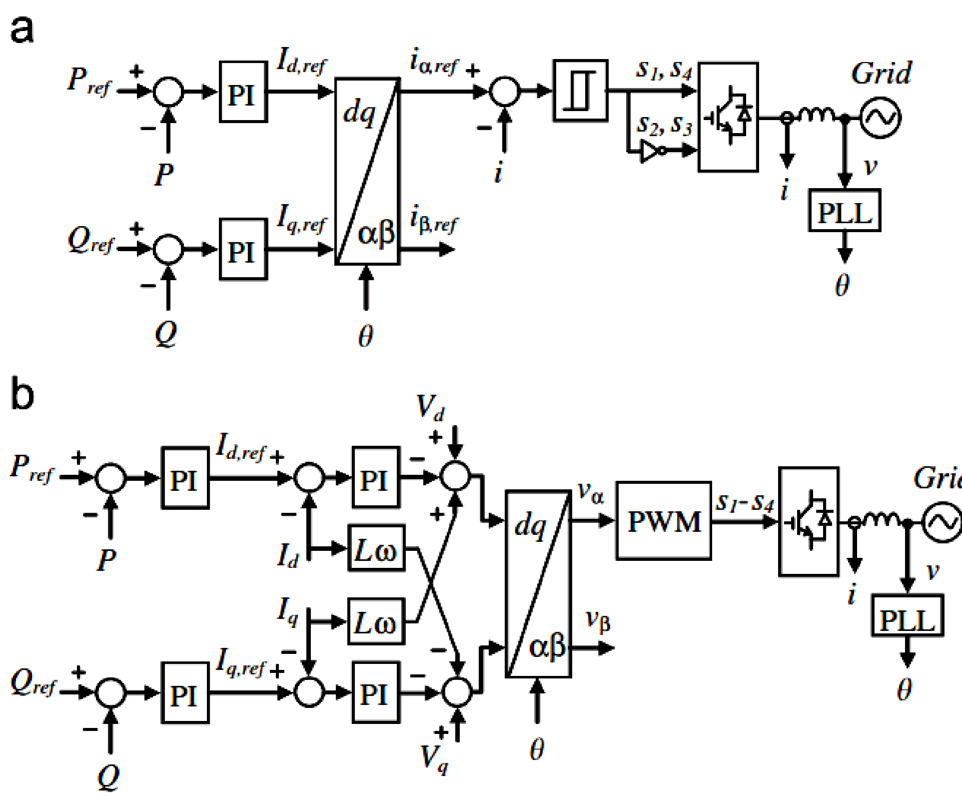

Figure 3 : **a)** CHC structure **b)** VOC structure

Advanced CHC methods are formed such that hysteresis bandwidth changes with system requirements and it caused switching with constant frequency. Of course this is at the expense of deterioration of the functional attributes such as increasing current harmonic, decreasing dynamic and lower stability level.

2.2. Voltage Oriented Control(VOC)

This method is known as “Indirect control of active and reactive current”. Based on the current vector direction with respect to voltage vector is formed. VOC method understands in the dq frame, where error between parallel and perpendicular of current is given to PI controller with the reference values. Since this controller produces the reference voltage for converter and it is applied to it with PWM.

This method in comparison with CHC method is that constant switch frequency can reduce switching losses, current distortion and THD to minimum. Also according to the internal current control ring, the dynamics of system is guaranteed.

One of the most important problems of this method is extreme dependence on current control strategy. We will see in this method, signals can be transmitted into the synchronous reference frame, where the values in the form of DC and the steady-state error are guaranteed by PI controller. This method requires at least two perpendicular current components, so we need to produce a virtual component.

3. Simulation In Matlab/Simulink

For study these two method we use Matlab/Simulink for simulation.

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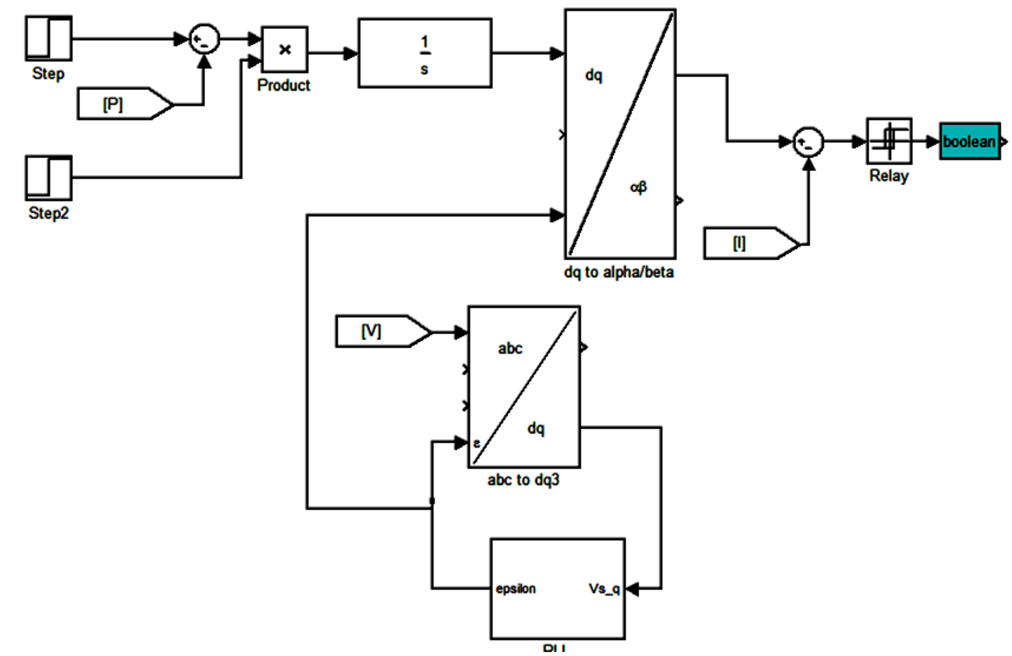

Figure 4 : CHC control section

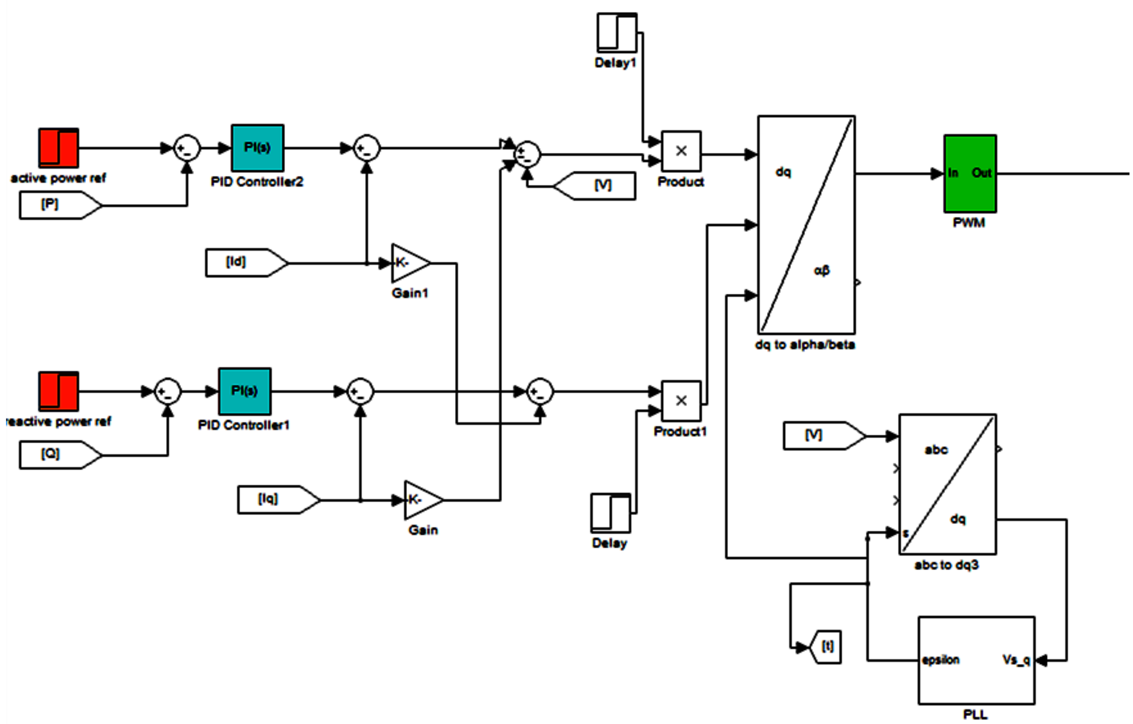

Figure 5 : VOC control section

We use a 0.2ms delay for PLL (Phase Lock Loop) to find the exact angle and frequency of grid side. It can be seen in CHC with step2 block and in VOC with Delay1&2. We also use Park's transformation so that we can make a sinusoidal reference from constant value of dq current error and with the same angular velocity as grid voltage. Value of parameters that we use in this simulation is given in table 2.

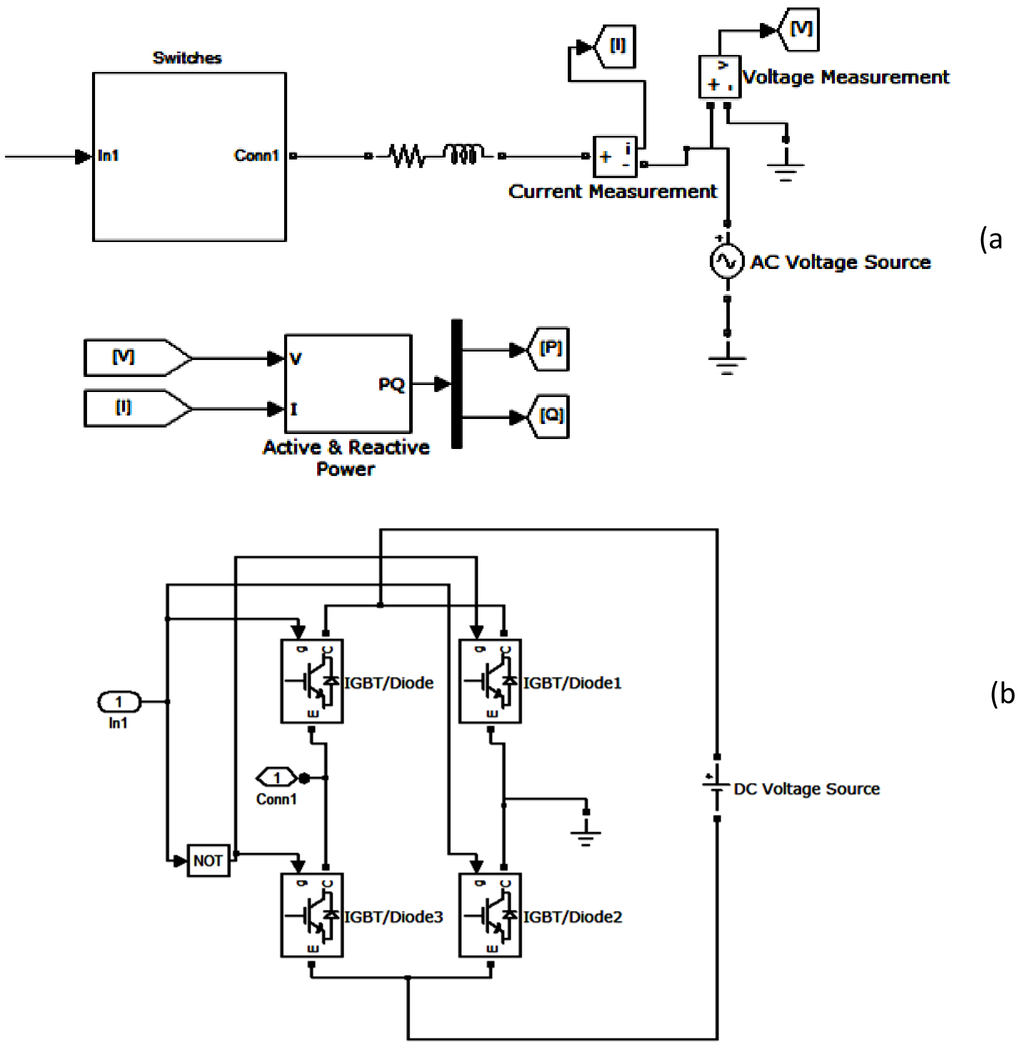

Figure 6 : a) power side of converter that is same in CHC and VOC b) switches Structure

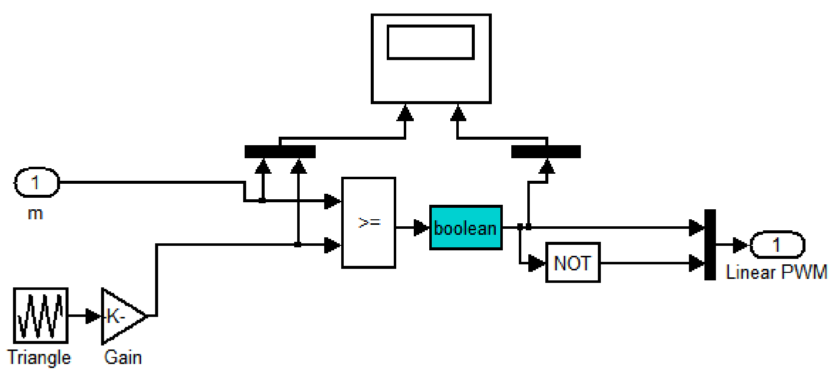

Figure 7 : PWM that is used in VOC method

TABLE 2: SYSTEM PARAMETERS

Parameter	Value
Active Reference Power	1000w
DC Voltage Supply	200V
Grid Voltage (Max)	70V
Grid Frequency	50Hz
Inductance of Filter	3.7 mH
Resistance of Filter	250 mΩ

4. Simulation Result

Result of simulation shows that the output values follow exactly the reference and simulation successfully implemented. In the following we bring this result:

4.1. CHC

In Figure 10 input wave (yellow) and the limit of hysteresis block (the red dashed line) can be seen. In this simulation the range of current varying set in plus/minus 0.1.

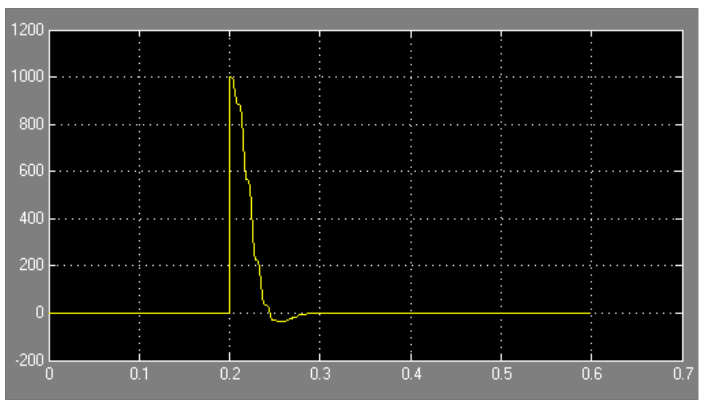

Figure 8 : error signal before integrator block

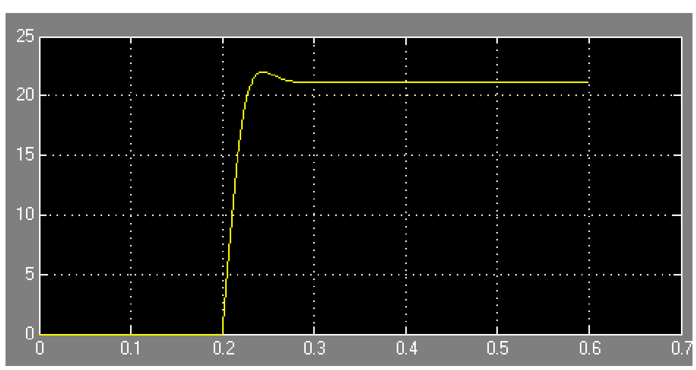

Figure 9 : above signal after integrator

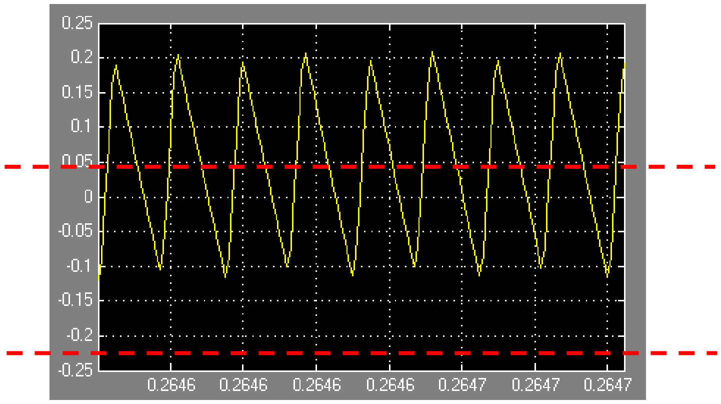

Figure 10: input of Hysteresis block

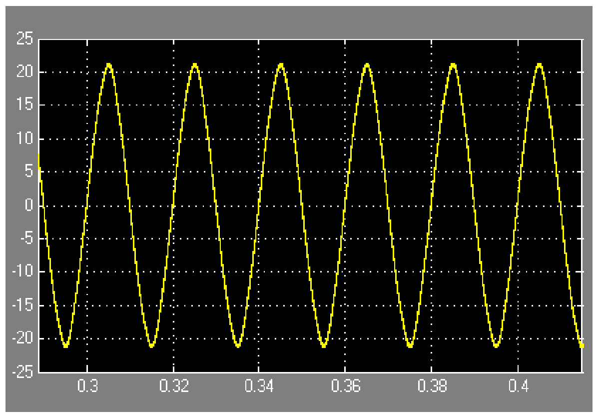

Figure 11 : output current

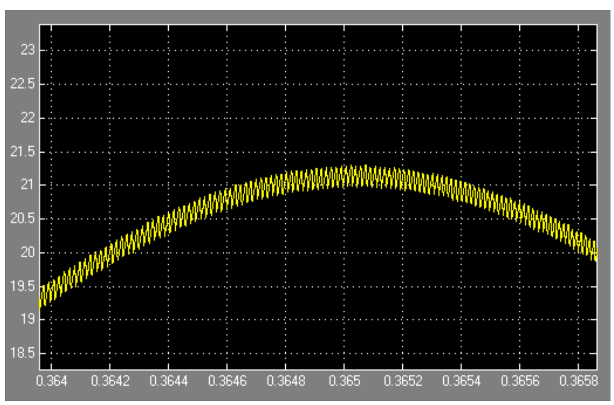

Figure 12 : current Variations in Hysteresis domain

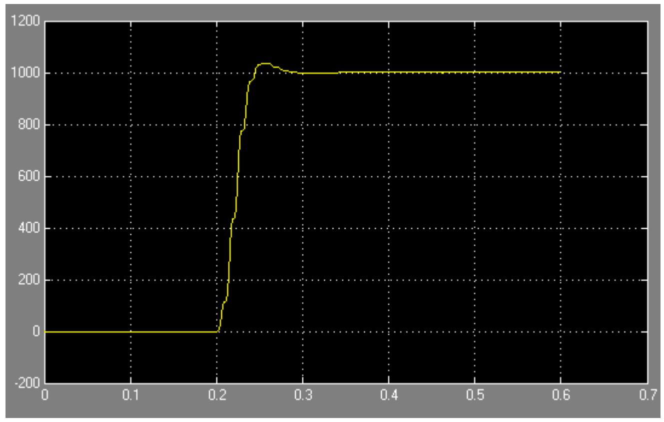

Figure 13 : output active power

4.2. VOC

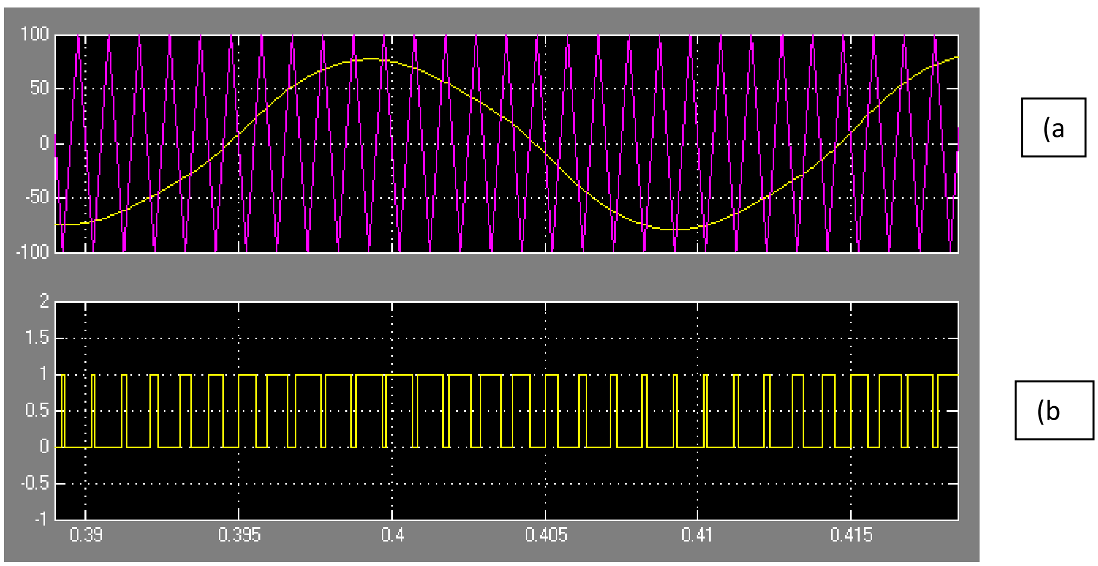

Figure 14 : **a)** input wave to PWM(yellow) and PWM Triangular wave (Purple) **b)** PWM switch state

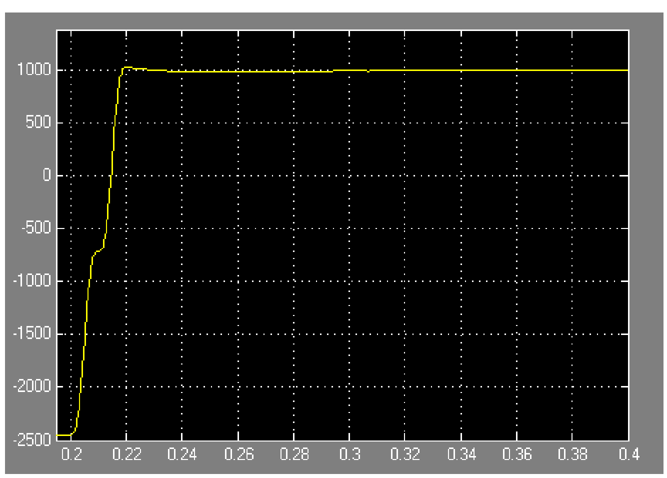

Figure 15 : output active power

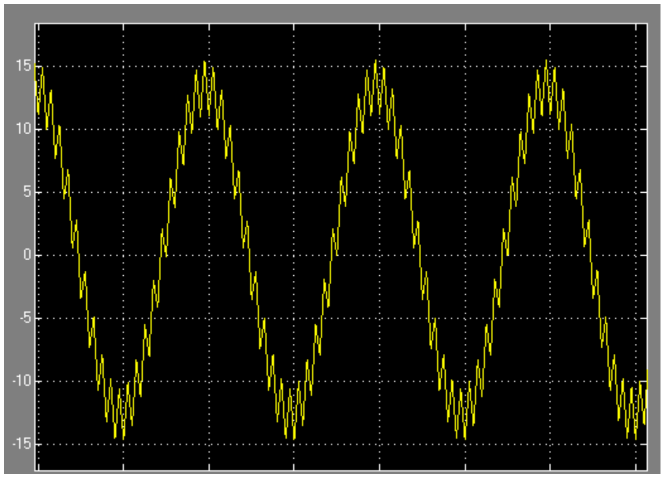

Figure 16 : output current wave

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Conclusion

In this paper we study two conventional current control methods .each method has its pros and cons. With considering the result it can be understand that CHC has simple structure and it can be made easier and cheaper with a Reasonable harmonic (THD=3.4%) but the variation in switching frequency has problems that was introduced. in the other hand VOC has a fixed frequency but complex structure. Here we bring some pros and cons of these two methods that we faced in this paper.

TABLE 3 : CHC AND VOC ADVANTAGES AND DISADVANTAGES

Methods	Advantages	Disadvantages
CHC	-simple structure -PWM block is not necessary	-Have a wide range of switching -frequency variation that make it hard to design filter and variation in switching losses.
VOC	-The switching frequency is fixed so power losses can be determine and designing filter is easy.	-A complex structure that make it hard to Implementation with parameters to tune. -Needing decoupling structure

References

[1] U.S. Energy Information Administration. Net Generation by Energy Source. U.S: EIA; 2014.

[2] "REN," in International Conference for Renewable Energies, bonn, 2011.

[3] World Energy Council. Survey of Energy Resources. London: World Energy Council; 2010.

[4] M. Kaltschmitt, T. Klinge, P. Kleineidam, Renewable power generation 2013, Renewable Energy Focus, vol. 15, no. 4, pp. 16--19, 2014.

[5] UNEP, in Global Trends in Renewable Energy Investment, Bloomberg, Frankfurt School, 2011.

[6] M. da S. Vilela, J. A. Vilela, L. C. de Freitas, E. A. A. Coelho, J. B. Vieira, and V. J. de Farias, "Proposal of a hysteresis control technique with almost constant frequency applied to the three phase boost converter," in Proc. IEEE Int. Symp. Ind. Electron., Jun. 2003, pp. 980–987.

[7] Dahono PA. New hysteresis current controller for single-phase full-bridge inverters. Power Electronics, IET 2009; 2 (September (5)): 585–594.

[8] F. Zare and G. Ledwich, "A new hysteresis current control for three-phase inverters based on adjacent voltage vectors and time error," in Proc. IEEE Power Electron. Spec. Conf., Jun. 2007, pp. 431–436.

[9] S. Buso, S. Fasolo, L. Malesani, and P. Mattavelli, "A dead-beat adaptive hysteresis current control," IEEE Trans. Ind. Appl., vol. 36, no. 4, pp. 1174–1180, Jul./Aug. 2000.

[10] Zang H, Yang X. 'Simulation of two-level photovoltaic grid-connected system based on current control of hysteresis band'. Power and Energy Engineering Conference (APPEEC) Asia-Pacific 2011; p. 1–4.

[11] Bahrani B, Rufer A, Lopes LAC. Vector control of single-phase voltage-source converters based on fictive-axis emulation. IEEE Transactions on Industrial Applications (March/April (2)).

[12] R. Wu, and G. R. Slemon, S. B. Dewan, "Analysis of an AC to DC voltage source converter using PWM with phase and amplitude control," in IEEE Trans Mar./Apr. 1991.

[13] Li P, Liu F, Gong JW, Chen BF, Zha XM. "Feedback decoupling and distortion correction based reactive compensation control for single-phase inverter" in Power Electronics and Drive Systems.

[14] G. Spagnuolo ,H. Petrone , and M. Vitelli, "A technique for improving P&O MPPT performances of double-stage grid-connected photovoltaic systems," IEEE Trans. Ind. Electron., vol. 56, no. 11, pp.

[15] M Calais, VG Agelidis, MS Dymond. 'A cascaded inverter for transformer less single- phase grid-connected photovoltaic systems' in Renewable Energy 2001 (January–March (1–3)).

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